



## Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

## THE MARINE FISHERIES, THE STATE AND THE BIOLOGIST

By WILL F. THOMPSON

MANY of the great marine fisheries of the world lie within the jurisdiction of more than a single sovereign country. The great North Sea fisheries, those of the Grand Banks, the salmon fisheries of the Fraser River (now nearly extinct), and the halibut fisheries of the North Pacific might be cited as examples. It would seem that this divided ownership has reacted most disastrously upon their care. Responsibility seems in such cases to be simply lost, not divided, and the net effect is that no one cares to sacrifice his own interests to maintain the fishery for the benefit of all. The splendid scientific work done in the North Sea contrasts vividly with the relative futility of the movement to conserve the vanishing bottom fisheries there by regulatory laws. There is simply no machinery capable of overriding the selfish interests of the few in each country, supplemented as it always is by the general suspicion one nation seems to think it necessary to have of every other nation.

The case seems far more hopeful, where there is no division of authority. And in many of our great states fisheries exist which are entirely under the legal control of a single state government.

That is true in California, where there is not a single fishery common to both its own water and the waters of another state or country save of the sparsely inhabited desert of Lower California, to whose less exploited fisheries vessels often go from Southern California ports. There is thus no possibility of shirking responsibility—the care of its fisheries devolves upon California alone by virtue of the Constitution of the United States and of its geographical position. No question of nationalism can be involved, only that of sectionalism. As a result, the failure to conserve the fisheries for the people of the entire state can result only from faulty organization of public opinion and the lack of real proof of the necessity of conservation.

The securing of this proof of the condition of the fisheries has in California, as everywhere else, been recognized as a legitimate function of the responsible government, and *the proper execution of that function is vital to the success of any popular movement toward conservation.* Unlike the forests and the mines, private ownership has never been granted in the fisheries, save in the case

of oysters and those of certain fresh waters, and for that reason aroused popular opinion is entirely likely to control in the end. But powerful interests have grown up who will vigorously object to curtailment of their activities. Something tantamount to legal proof is necessary before what seems to them confiscation may be indulged in. And they have in the past shown a vitality which augurs ill for any but well-based movements toward conservation.

The general policy of conservation is, moreover, largely supported by men among the public who are not trained scientists and do not know the value of evidence. Their conclusions as to the existence of depletion may carry weight where, as in the case of birds and mammals, any honest man may observe conditions with his own eyes, and where powerful interests are not placed in jeopardy. But in the marine fisheries this is not true, for the fish are not easily observed and the evidence must come from statistical proof of comprehensive character. Under such circumstances the cry of conservation, raised hysterically and hastily, as is done even by scientists at times, must in the long run lead to failure and the injury of the cause at stake. And measures of regulation or restriction passed in response to pleas made on an insecure basis must in the end fail to justify themselves. So the acquirement of real knowledge, while a protection to the men legitimately engaged in exploitation, is equally such to the cause of conservation itself, for it should not only prevent this lack of balance and undue regulation, but it should prevent the growth of interests which must later be curtailed.

This necessity of knowledge was acknowledged by the fishery authorities of the State of California when they instituted the present system of observing the fisheries. Their action in this regard was based on the following facts: First, that enough accurate knowledge already exists to prove the susceptibility of marine fisheries in general to overfishing; second, that proof is required in the case of each individual fishery, and that there is no way of knowing the strain a species will stand save by submitting it to one; third, that such a course of action implies the duty of the state to maintain a constant and intelligent ward over its fisheries; and finally, that such a ward is possible and that it implies continuous and prolonged statistical and biological investigations.

In regard to the first point, the existence of proof that marine fisheries are exhaustible, we must turn to the oldest and best known of fisheries, namely those in North European seas. Contrary to the opinions of many, these great fisheries cannot justifiably be called ancient. The use of steam vessels began in 1880; the otter trawl first came into use in 1895, laying open to exploitation the depths of the ocean below fifty fathoms; while the means of mar-

keting and the extent of the demand increased equally with the recent great industrial expansion. The latter involved the development of railroads, the refrigeration of food products, the use of cans for their preservation, fast steamships to carry them, the growth of city life as a market, etc. Meanwhile, as cited by Jenkins ("The Sea Fisheries," 1920) as an illustration of the trend of the times, the number of fishing vessels in the port of Aberdeen, Scotland, increased 258 per cent. in the period 1897-1903, and according to the estimate of the same authority, agreeing with that of others, the efficiency of each steam trawler of to-day exceeds eight times that of the sailing trawler it displaced (aside from the independence the steamer has of weather and distance). The fisheries in other parts of the world are still more recent, and show the same great increase in apparatus although not necessarily in catch. If these facts are considered, it is impossible to doubt that, unless civilization comes to an abrupt pause, with the destruction of our highly developed transportation and of our industrialism which builds towns and markets, we are on the brink of an era of exploitation of our fisheries, and not at the crest of such an era. And the existence of overfishing now becomes a serious problem, for if the fisheries do show depletion, it is indeed a serious question whether they will, even in their more stable parts, survive the coming strain. Faith in our destiny and that of the world implies care of our resources of fish.

That they do show depletion in certain fisheries is now proved. The most clearly ascertained instances at present are those of the bottom fisheries. Thus the halibut in both the Atlantic and the Pacific has decreased with great rapidity. But the bottom fisheries of the North Sea for plaice and other allied species are, as Garstang ("The Impoverishment of the Sea," 1900) says, "not only exhaustible, but in rapid and continuous process of exhaustion." This conclusion has been seconded and supported by men who have, in the various countries around the North Sea, actually had the examination of the statistics in their care, as Heincke, Fulton, Thompson and others, such as Jenkins and Allen. And if these bottom fisheries already show exhaustion, since they are more stationary, are most highly valued, and were first sought for, it is not to be expected that "pelagic" fish will show otherwise upon the imposition of greater strain, even though they are more abundant. But in this connection, it must, indeed, be remembered that there is no accurate means of determining whether pelagic fish actually are more abundant than other fish in the ocean—although we do know that the cod and the herring, for instance, are not numberless, as some estimates have made them.

Against such a view there has been urged the objection that

the fisheries seem to be prospering and to be continuing on a firm basis. That fact may be granted, however, without conflicting with the above conclusions. It may be admitted that the total yield of the fisheries does not everywhere seem to decline, but it can be proved that continuously greater toil is required to obtain it. That this decreasing yield for the effort involved does not attract more attention should be understandable when it is considered that the cost of catching fish is but a fraction of the cost of distribution. Thus the fisherman may receive eight cents per pound where the retailer asks forty cents, and doubling the fisherman's price would add but a fifth to the retailer's price. The cost of obtaining the fish could be multiplied many fold without seriously affecting the final price to the consumer. The latter is, moreover, willing to pay high prices for a product to which he has become accustomed, and the rarer it is the more he will pay. The increase in initial cost does not seem, in fact, to be of the greatest importance.

There is also this fact to be taken into consideration, that there are influences which actually counteract the effect of increasing scarcity in raising the initial cost. The accompaniments of that intensified exploitation which results in depletion are the constant broadening of the fishing grounds, the inclusion of more than one species of fish and of inferior quality in the catch of the boats, the development of means of preservation, the constant improvement of gear and the increase in quantity of apparatus. All these things tend to eliminate the great and sudden fluctuations in amount of yield which are characteristic of fisheries confined to one species or one locality. These variations in yield render the exploitation of the fisheries expensive and uncertain because the periods of abundance must be made to pay interest upon the capital and to maintain the organization during periods of scarcity. Their elimination as a result of intense fishing undoubtedly does reduce the cost of fish to the consumer, perhaps to the extent that for a while the influence of depletion in raising the initial cost will not be felt.

But in the end that very fact may defeat the natural safeguard which should protect a species, namely, the lack of profit in carrying on a fishery when it comes dangerously near to exhaustion. It becomes possible to prolong a fishery because other species are taken; the by-product becomes the mainstay of the business and the depleted species is kept under a strain for which it could not itself pay. If it were not for cod, perhaps the halibut fishery of Iceland might have long since collapsed; and if it were not for the cheaper round fishes, the flat fishes in the North Sea might be pursued far less rigorously. On the Pacific coast, the tuna and sardine

fishery of California may have been of considerable assistance to the albacore fishery. In fact, the objection often raised to the possibility of over-fishing that the fisheries are prospering and that they would immediately cease to prosper should depletion occur is not a valid one. But that they would ultimately fail as a result of over-fishing seems sure.

Another basis for scepticism as to the reality of the fact of possible exhaustion has been the seeming boundlessness of the sea and its resources. But every fisherman knows that the areas within which fish of a given species are found are very limited, perhaps less so in the cases of "pelagic" fishes than in those of "demersal," yet highly limited nevertheless. And the scientist will testify to the sharp limitations which temperature, depth, salinity and currents place upon every species, so that it is in reality only a very small part of the ocean which yields our commercial fishes. They are, in fact, limited largely to the area of the coastal regions or the continental shelf, where there is drainage from the land, and to comparatively small parts of that shelf. In so far as this productive area is concerned, Gran and others have remarked that it corresponds in general with the distribution of the minute plankton organisms which are vastly more abundant where coastal water is found; and upon these plankton organisms fish must necessarily exist in the final analysis. And even where conditions are thus favorable, and the fisheries are highly developed, as in the North Sea, Allen ("Food from the Sea," 1917) estimates that an acre yields but fifteen pounds of fish per year while pasture land yields seventy-three pounds of beef. In accordance with these facts the experiments which have been made in marking fish and observing the frequency of recapture have shown that the fishermen are able to take, and do take, a very high percentage of the bottom fish in the North Sea. What they do with other fish, such as the herring and the sardine, or in any other regions, is for the most part unknown. It is therefore a mistake to assume that the resources of the sea are inexhaustible, or that over-fishing characterizes small areas easily replenished from without.

There is, indeed, no manner of gauging in advance the productivity of the ocean, in so far as edible fish are concerned. It is in the first place obvious to students of the matter that the amount of food present for fishes does not determine abundance, any more than the amount of grass did determine the abundance of the buffalo on our plains, or of deer in our forests. But it is certain that the rate of reproduction varies widely, and with it the relative resistance to depletion of the species of fish. Such matters as egg production, length of life, varying mortality at different stages and time of sexual maturity must all be taken into account, together

with the sharp limitations provided by climatic and geographical conditions. Moreover, the relative amount of competition for the available food is unknown, although we do know that the commercial fishes are probably but a small part of the population to be supported by the sea. And even if the abundance of the species were a gauge to its resistance to a strain—which it does not necessarily have to be—there is thus far no method of accurately ascertaining the abundance of any one species of fish or of all together save within limited areas of the ocean. It seems, indeed, that there is no method of measuring the amount of fishing a species will stand save by submitting it to a strain.

The only hint which can be obtained concerning the limits of the fisheries in California come from a comparison of the productive area with that of the North Sea, where the bottom fisheries show decline. It is, however, very hard to define the productive area, save by the width of the continental shelf. The area within the one hundred fathom line in the North Sea is approximately 130,000 squares miles (nautical), while off the coast of California it is about 7,500 square miles. In the former case this area is about 300 miles wide and 450 long, but in California the average width is but 8.4 miles, much of this rocky or unsuitable for bottom fishes. In this connection it must be recollected that, as cited above, Gran and other authorities regard the presence of coastal water with land drainage in it as essential to the production of abundant planktonic life. Such water is abundant off the coast of Europe, but the California coast is more arid in nature, especially the southern portion. However, the great fisheries of California are of the "pelagic" type, regarding which such speculation may be limited in value. Nevertheless, it is probably safe to say, when all is taken into consideration, that these fisheries are far more limited in proportion to length of coast line than is the case in the North Sea, and hence much more susceptible to overfishing.

As has been said above, the possibility and actuality of overfishing have been definitely proved, yet it seems true that there is no arbitrary limit which can be economically assigned to any fishery. It would be indeed sheer waste to impose a limit below what might be safely taken and the alternative is plain, to allow the imposition of all the strain the species will carry. It is, as a matter of fact, the only politically practical course of action, at the same time being the correct one from the scientific standpoint.

But it must not be forgotten that the acceptance of such a fact implies the serious duty of close observation and prompt action, in case of overfishing, by the government in control. That is

clearly recognized by the fishery authorities of California and is the mainspring of their actions.

These things having been recognized as true, it followed that a careful survey of measures necessary for such observations was in order, and this has been made in so far as possible. For such purposes the great mass of literature published by the various countries around the North Sea was available, especially that issued by the "Conseil Permanent International pour l'Exploration de la Mer," or inspired by it. It soon became evident that it was impossible for the State of California to undertake the many lines of general inquiry into the varying conditions of the sea and its life which had been investigated more or less by these European countries. That would have been tunnelling the mountain by removing it in its entirety. It was necessary for the state to limit its efforts to those fields which had been shown to bear directly on the ascertainment of the condition of the fisheries; namely, the measurement of the variance in abundance of the fishes in the sea, the effects of fishing upon it and the biological criteria of over-fishing. A careful perusal of much of the hydrographic and planktonic work demonstrated its remoteness from the work in hand despite its undoubtedly great ultimate value, and showed that most of the immediate questions could be solved to the required degree without their aid. There were necessary certain biological studies upon the fishes themselves, but above all a statistical study of the fisheries and the fish.

This method of approach, as Johan Hjort has most appropriately said of a certain phase of it, is regarding the study of the fisheries in a similar light to the study of the vital statistics of mankind. It involves primarily the taking of what amounts to a comparative census from year to year in order to test the relative abundance—not the actual abundance—of fish; then to determine whether such great fluctuations as appear are due to natural causes or to overfishing.

For this program, the legislature of the state has passed laws taxing the fisheries industries fifty cents per ton of raw fish used for canning, and has definitely specified the duty of the agents of the state. It is unnecessary to give the details of these laws, but something as to their operation will be of use.

Every commercial transaction involving the first sale of fish is accompanied by the giving of a receipt by the buyer upon a form issued by the fish and game commission and of this receipt one copy is returned to the commission and another kept by the dealer. There are, therefore, actual records of all fish taken for profit, according to the boat and to the day. This unique system has been most successful in its operation for the last three years, avoiding

what we now know were widely erroneous estimates in statistics; while the fresh fish dealer has frequently for the first time a record of his own dealings. The results obtained have continuity, and are in such detail that market conditions, changes in apparatus or fishing fleets, etc., may be readily discounted. So every commercial fishing boat becomes in effect a means of testing the abundance of fish, and it is possible to segregate the effects of scarcity of fish from the effects of those economic changes which alter the total yield. This appears the necessary procedure from the experience of investigators in the North Sea, and is preferable to the limited experimental fishing which is possible. We do, in fact, feel confident that we will have a relatively accurate and sensitive record of the variations in abundance of fish in the ocean, when studied in connection with biological facts.

This scientific collection of statistics is the starting point and the foundation for further investigations. The interpretation of the evidence drawn therefrom is the duty of the biologists engaged by the commission; for the great fluctuations in abundance of fish which may be shown must be analyzed and their true nature discovered. Such natural fluctuations are very likely to be mistaken for depletion from overfishing; or, perhaps, if of opposite trend, as a contradiction of any theory of overfishing when they are in truth, as we have said, due to natural causes, and depletion may exist despite the temporary obliteration of the evidence. There must, as a consequence, be developed and utilized those biological criteria which distinguish depletion due to excessive fishing. The biological knowledge necessary for the use and formulation of such criteria includes among other things the determination of age, the discovery of migrations and in so far as possible the correlation of abundance with natural physical conditions. One may justifiably call it ecology on a vast scale. Granted a fair knowledge of these criteria, it is not exceeding the reasonable to hope that the fishery authorities will be able to give warning when depletion is occurring—and, indeed, unless a degree of confidence can be placed in the competency of the work, the exploitation of the fisheries should not be allowed to proceed freely, nor can freedom be had from the constant fear of ruthless exploitation.

There is, in addition, a need on the part of legislators for competent data upon which measures of regulation may be based. The imposition of arbitrary and reckless restrictions should be prevented by the acquisition of proper knowledge as soon as possible. At present many of our fishery laws are untenable from a scientific standpoint, save in so far as they actually operate to reduce the take. And even if it be said that legislatures will not take proper action, it would be a defeatist's attitude to take to

fail to provide them proper knowledge upon which they might take action. There are a great many legislators who will act along the line of their best knowledge, and more who will respond to intelligent pressure on the part of the public.

In thus accepting conservation as a major policy because of its dependence upon the legal powers of the state, the program adopted in California has not been oblivious of the fact that the work for that purpose has a very definite bearing upon some of the greatest problems of exploitation. As an example, the abundance of fish is subject to great natural fluctuations beyond the control of man. The return from the fisheries vary greatly from day to day, from season to season, and from year to year. The resultant waste is an exaggerated case of the same kind which the electrical engineer meets when he is faced with the "peak load" or maximum use of electricity during a short period each day. Just as apparatus must be available to carry this "peak load," so must the fish canners or dealers maintain the machinery and organization for brief periods of maximum supply and longer ones of scarcity as well as variations in demand which are disconcerting both to the dealers and consumers. The meat packers, their rivals, need not do this. The understanding of these fluctuations so that regularly recurring ones may be expected, others foretold and provision made to meet or avoid them, is without doubt one of the most neglected functions of government scientists. The proper study of depletion necessitates just such an understanding of these changes as will serve the industry.

It must be acknowledged that in adopting such a program, installing such a system of statistics and founding a California state fisheries laboratory at San Pedro to care for the biological science of the subject, the state of California is experimenting. It still remains to be seen whether popular support will be rendered the project, either on the part of scientific men or the general public. The field seems to be one in which the scientist, particularly the biologist, should welcome a chance to show how his work can be applied to the needs of humanity; but, aside from this, basic principles of animal life and behavior are really involved to such an extent as to satisfy the most academic of men and are attacked with the aid of vast masses of material unobtainable through any other source than the commercial fisheries. On the part of the public, it would seem that only a failure to understand or lack of faith in the competency of the work could lead to lack of support.

It is sincerely to be hoped that this effort to approach the problems of conservation upon a rational and well-balanced basis will meet with the reception its sincerity deserves.